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THE GEODETIC WORK OF THE HAYDEN AND WHEELER SURVEYS.

THE publication of the final results of the triangulation of these surveys furnishes the material for a direct comparison between them, inasmuch as the two surveys covered in duplicate large areas of country. Fully one-half the mountain area of Colorado, and a large extent of country in north-eastern Utah and south-eastern Idaho, have thus been surveyed in duplicate. An examination shows, that in the former area no fewer than twelve points have been occupied in common as geodetic stations, and their positions published by each organization. The following are the points in question, with the latitudes and longitudes as given by each survey, the determinations of the Hayden survey preceding in each case. The names in parentheses are those given to the points by the Wheeler survey.

STATIONS.	Latitude.	Longitude.
Blanca	37° 34' 43".5	105° 28' 55".4
Pagosa	37 34 37.0	105 28 57.0
Rio Grande Pyramid (Simpson)	37 26 43.1	107 3 47.2
Uncompahgre	37 26 37.0	107 3 50.0
Ouray (Hunts)	37 40 52.2	107 23 19.2
Agency Knob	37 40 46.0	107 23 22.0
Wilson (Glacier)	38 4 23.0	107 27 30.1
Leon	38 4 18.0	107 27 33.0
South River (Macomb)	38 25 26.1	106 13 15.7
Summit (Meigs)	38 25 20.0	106 13 18.0
Sneffels (Blaine)	38 16 30.7	106 51 47.6
Banded	38 16 24.0	106 51 54.0
	37 50 26.4	107 59 16.9
	37 50 21.0	107 59 20.0
	39 4 51.0	107 50 24.7
	39 4 45.0	107 50 27.0
	37 34 31.7	106 58 40.2
	37 34 25.0	106 58 43.0
	37 21 7.3	106 41 35.4
	37 21 1.0	106 41 39.0
	38 0 19.0	107 47 18.7
	38 0 14.0	107 47 22.0
	37 6 21.6	106 37 24.5
	37 6 16.0	106 37 27.0

The following are the discrepancies between the above results :—

STATIONS.	DISCREPANCIES.	
	Latitude.	Longitude.
Blanca	6".5	1".6
Pagosa	6.1	2.8
Rio Grande Pyramid	6.2	2.8
Uncompahgre	5.0	2.9
Ouray	6.1	2.3
Agency Knob	6.7	6.4
Wilson	5.4	3.1
Leon	6.0	2.3
South River	6.7	2.8
Summit	6.3	3.6
Sneffels	5.0	3.3
Banded	5.6	2.5

It will be seen that the discrepancies in latitude are quite constant, ranging from 5".0

to 6".7, the Hayden latitudes being in every case the greater; and that the discrepancies in longitude are almost equally constant, ranging, with the exception of one case, from 1".6 to 3".6, the Hayden longitudes being in every case the smaller. The comparatively large discrepancy in the longitude of Agency Knob is explainable by the fact, that, from most points of view, this station presents an ill-defined summit. The constancy of these discrepancies points to the fact, that they are in the main due to station-error, as is unquestionably the case. The Hayden work was based on Denver as determined astronomically by the U. S. coast and geodetic survey, while the Wheeler work depends upon Colorado Springs as determined by the Wheeler survey. The relative station-error of these two places has not been determined directly, but cannot fail to be considerable, owing to the difference in their surroundings.

Assuming that the difference in station-error between Denver and Colorado Springs is, roughly speaking, equal to the average difference between the Hayden and Wheeler work (leaving out Agency Knob),—i.e., 5".9 in latitude, and 2".7 in longitude,—and correcting one of the two above sets of results therefor, the discrepancies between them become as follows :—

STATIONS.	DISCREPANCIES.	
	Latitude.	Longitude.
Blanca	0".6	1".1
Pagosa	0.2	0.1
Rio Grande Pyramid	0.3	0.1
Uncompahgre	0.9	0.2
Ouray	0.2	0.4
Agency Knob	0.8	3.7
Wilson	0.5	0.4
Leon	0.1	0.4
South River	0.8	0.1
Summit	0.4	0.9
Sneffels	0.9	0.6
Banded	0.3	0.2

The mean of these differences in latitude is but 0".55, and in longitude, with the exception of Agency Knob, but 0".41.

The area surveyed in duplicate north of the Union Pacific railroad in north-eastern Utah and south-eastern Idaho does not show quite so close accordance in results. The Hayden work here depends upon the astronomical determination of Salt Lake City by the U. S. coast and geodetic survey, and is checked upon the determination of Ogden by Wheeler's survey, upon which the Wheeler work rests. This check shows little or no difference in station-error between the two astronomical stations. The following are the positions of five points

occupied in common by the two surveys, as given by Hayden and Wheeler, the determinations of the former preceding:—

STATIONS.	Latitude.	Longitude.
Putnam, Idaho	42° 57' 10".6	112° 10' 9".4
Preuss (Meade), Idaho	42 58 8 .0	112 10 10 .0
Soda (Sherman), Idaho	42 29 42 .6	111 15 11 .0
Caribou (Pisgah), Idaho	42 29 41 .0	111 15 11 .0
Willard (North Ogden), Utah	42 27 53 .7	111 33 11 .4
	42 27 52 .0	111 33 11 .0
	43 5 36 .2	111 18 56 .7
	43 5 34 .0	111 18 58 .0
	41 21 44 .9	111 57 53 .1
	41 21 45 .0	111 57 53 .0

The following are the differences between the two sets of results:—

STATIONS.	DIFFERENCES.	
	Latitude.	Longitude.
Putnam	2".6	0".6
Preuss	1 .6	0 .0
Soda	1 .7	0 .4
Caribou	2 .2	1 .3
Willard	0 .1	0 .1

The average differences are respectively 1".6 and 0".5.

It is to be regretted that the distances between these points, as determined by the Wheeler survey, are not available, in order that a more direct comparison might be made.

It should be understood that the object of each of these systems of triangulation was simply and solely to furnish adequate control for topographic work, to be published on a scale of four miles to an inch, or about $\frac{1}{250000}$. A greater degree of accuracy than was required for this purpose was not contemplated. In all cases natural points were used as signals until the stations were occupied, when rude cairns of stone, six to eight feet in height, were erected, and used thereafter as signals. The Hayden work was carried on with an eight-inch theodolite, reading to 10"; and the work was adjusted by a graphic method, with foresights only. The area triangulated by this survey aggregated nearly a hundred and twenty thousand square miles; which work, besides the measurement and expansion of four base-

lines, was done by one party in six field-seasons, each of four months' duration. As a rule, all the work upon a station was completed in a few hours. The general character of the Wheeler work was very similar to that of the Hayden survey, except that the adjustments were made by least squares.

HENRY GANNETT.

THE DEEP-SEA DREDGING APPARATUS OF THE TALISMAN.¹

THE first French deep-sea exploring expedition was made in 1880 by the *Travailleur*, in the Bay of Biscay. The following year the *Travailleur* was again put at the disposal of the commission over which Mr. Milne-Edwards presided; and the party traversed the Bay of Biscay, visited the coast of Portugal, passed the Strait of Gibraltar, and explored a large part of the Mediterranean. In 1882 the same vessel undertook a third expedition into the Atlantic Ocean, and proceeded as far as the Canary Islands. But the *Travailleur*, being a despatch-boat for harbor use, did not possess the requirements for making long voyages; and accordingly the *Talisman*, a cruiser, was equipped for a new dredging expedition, and left the port of Rochefort on the 1st of June, 1883, with Mr. Milne-Edwards and the commission appointed by the minister of public instruction on board. The *Talisman* explored the coasts of Portugal and Morocco, visited the Canaries and Cape Verde, traversed the Sargasso

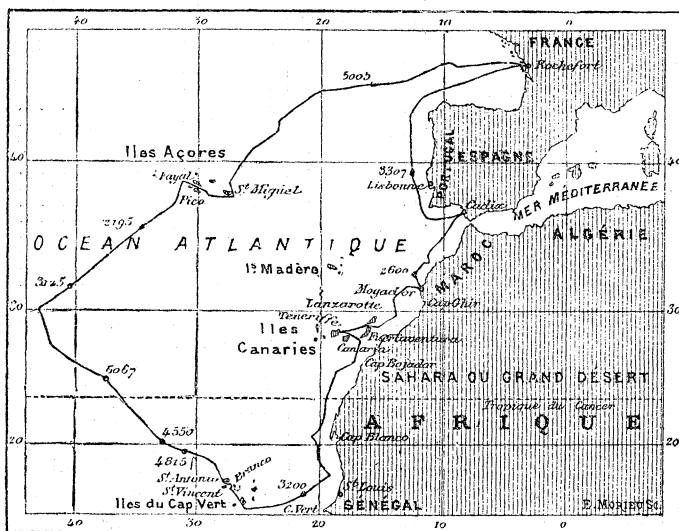


FIG. 1. — Course of the *Talisman*.

Sea, and, after remaining some time at the Azores, returned and explored the Bay of Biscay (fig. 1).

On the bridge of the *Talisman* there had been

¹ Condensed from an account in *La Nature*. By H. FILHOL.